

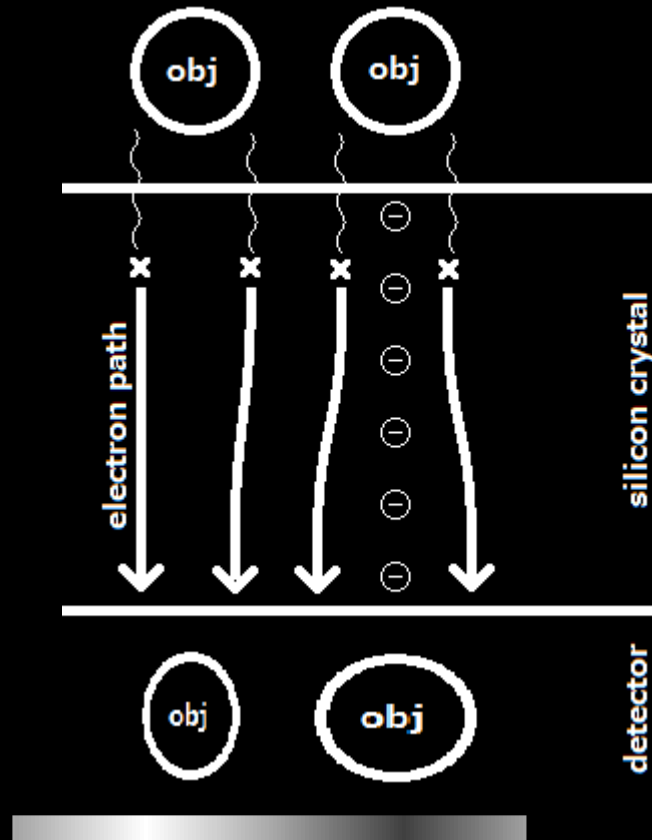
Spurious shear from Tree Ring on DECam

Yuki Okura

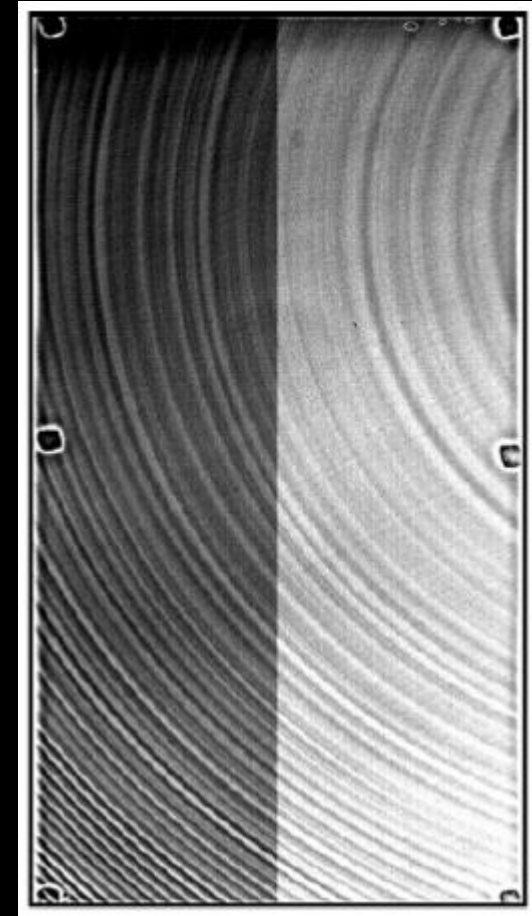
- Tree Ring on DECam
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Tree Ring on DECam

- Tree Rings are caused by concentric impurity in silicon crystal, then the impurity makes electric field and bends electron path. As the result of the bending, flat images have bright and dark region which looks like a tree ring pattern and object images are distorted.



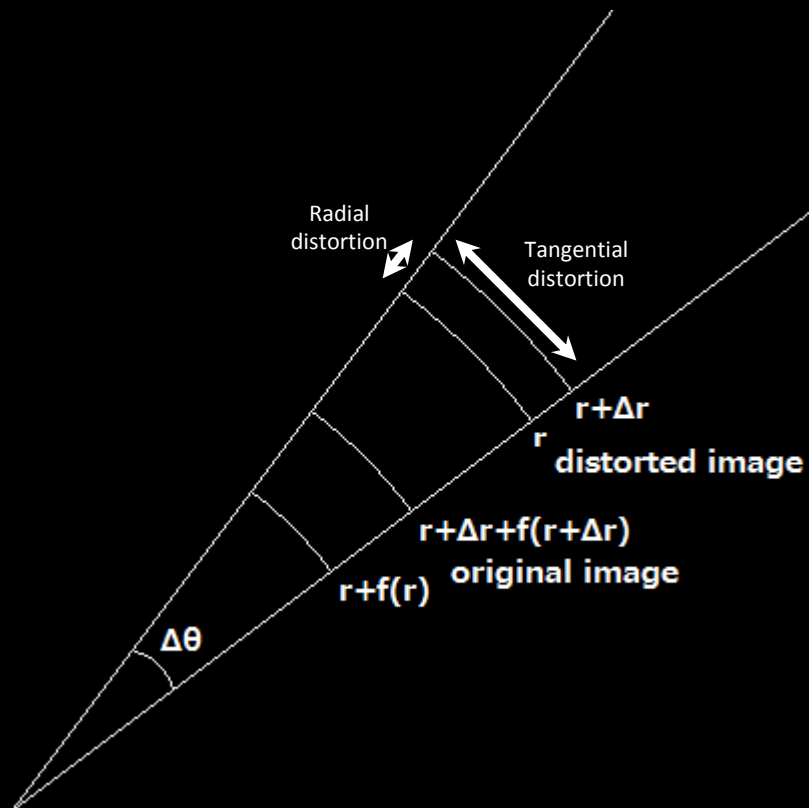
Bending electron path



Flat image of DECam CCD
(Plazas et al., 2014)

Distortion from concentric displacement

- Distortions by displacement are calculated easily if the displacement is concentric. This calculations can be seen in strong lensing study.



Distortion by concentric displacement

Tangential distortion

$$\frac{f(r)\Delta\theta}{r\Delta\theta} = \frac{f(r)}{r}$$

Radial distortion

$$\frac{f(r + \Delta r) - f(r)}{r + \Delta r - r} = \frac{\partial f(r)}{\partial r}$$

Lensing convergence and shear

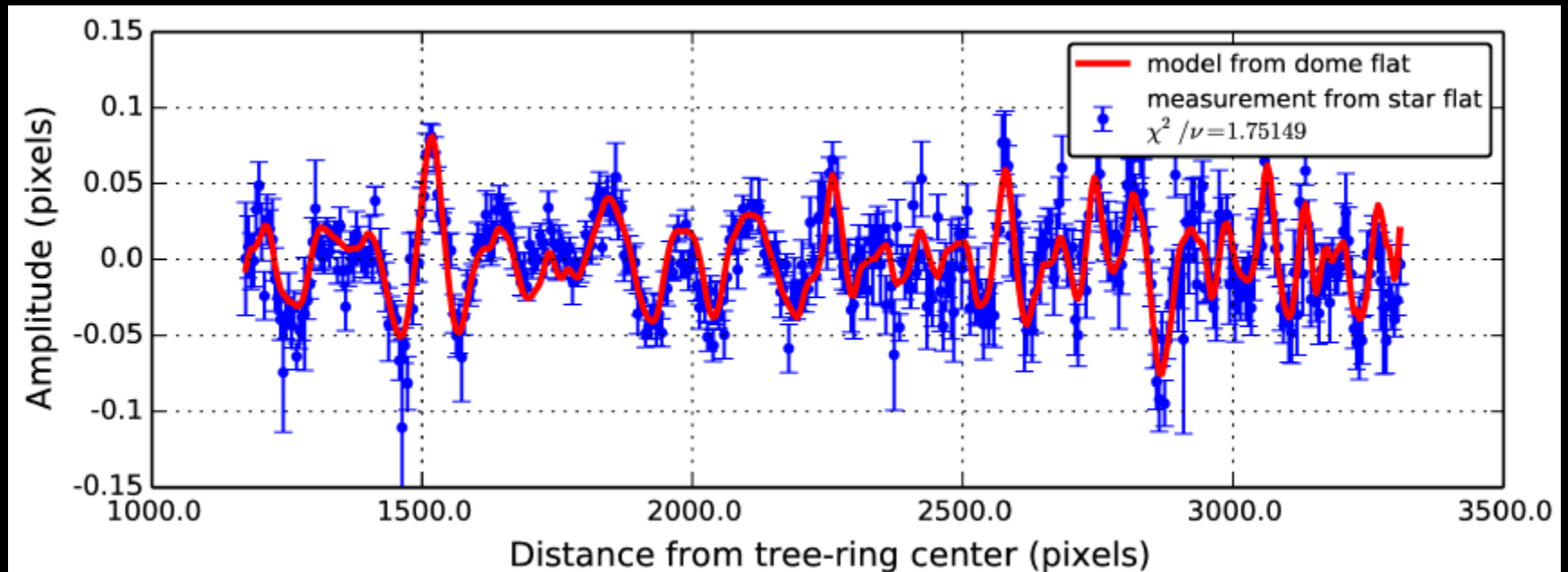
$$\kappa = \frac{-1}{2} \left(\frac{\partial f(r)}{\partial r} + \frac{f(r)}{r} \right)$$

$$\gamma = \frac{-1}{2} \left(\frac{\partial f(r)}{\partial r} - \frac{f(r)}{r} \right)$$

- We need differential function of $f(r)$ for estimating spurious shear.

Displacement model from dome flat

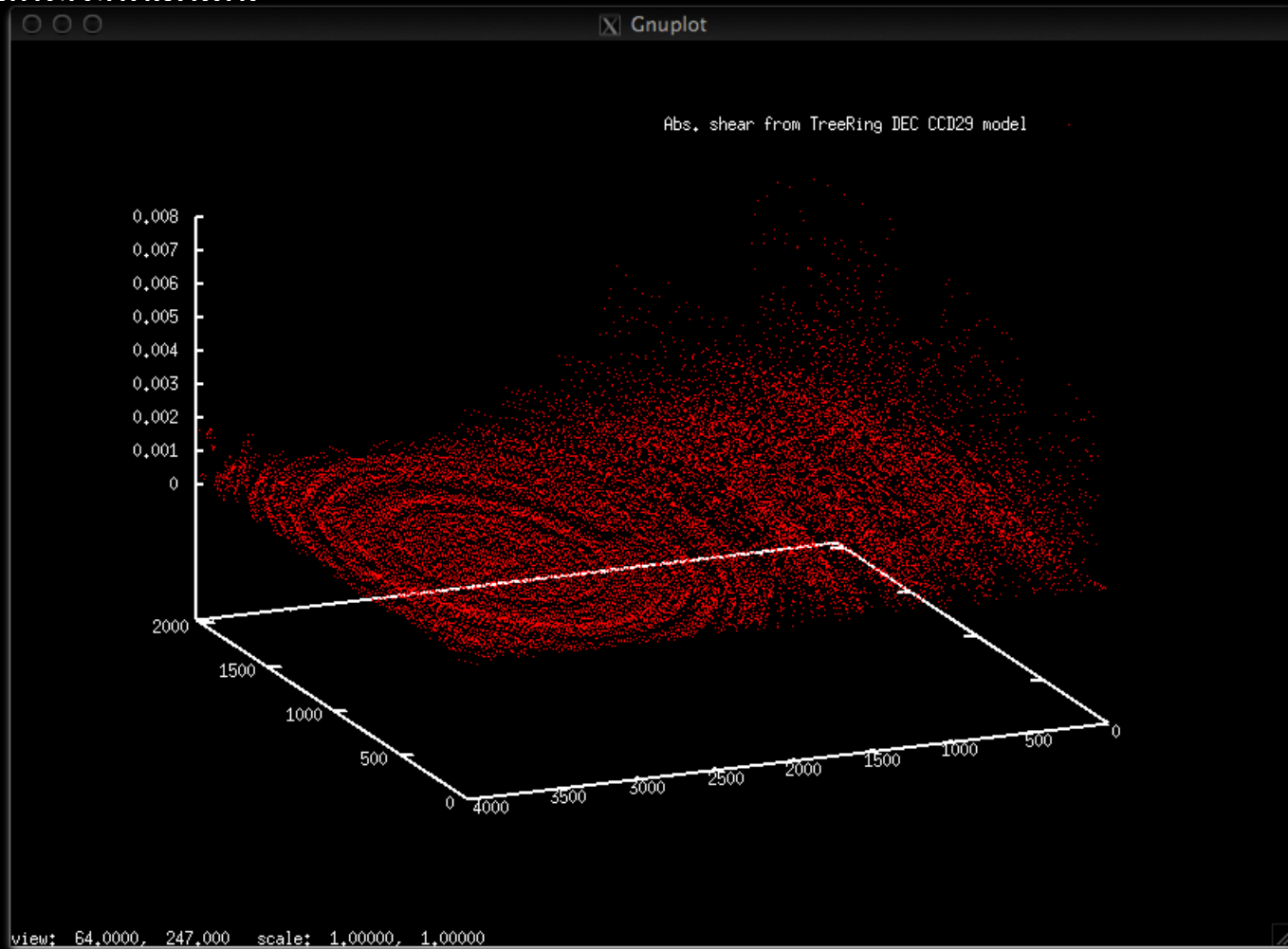
- It is hard to measure the displacement directly, but it is easy to measure fluctuation of flat image, so Andres made a formula which estimates the displacement from the fluctuation(Plazas et al., 2014).
- This figure is Andres's result of modeling of the displacement from dome flat.



The predicted displacement from flat image and measured displacement
(Plazas et al., 2014)

Shear from Tree Ring Model

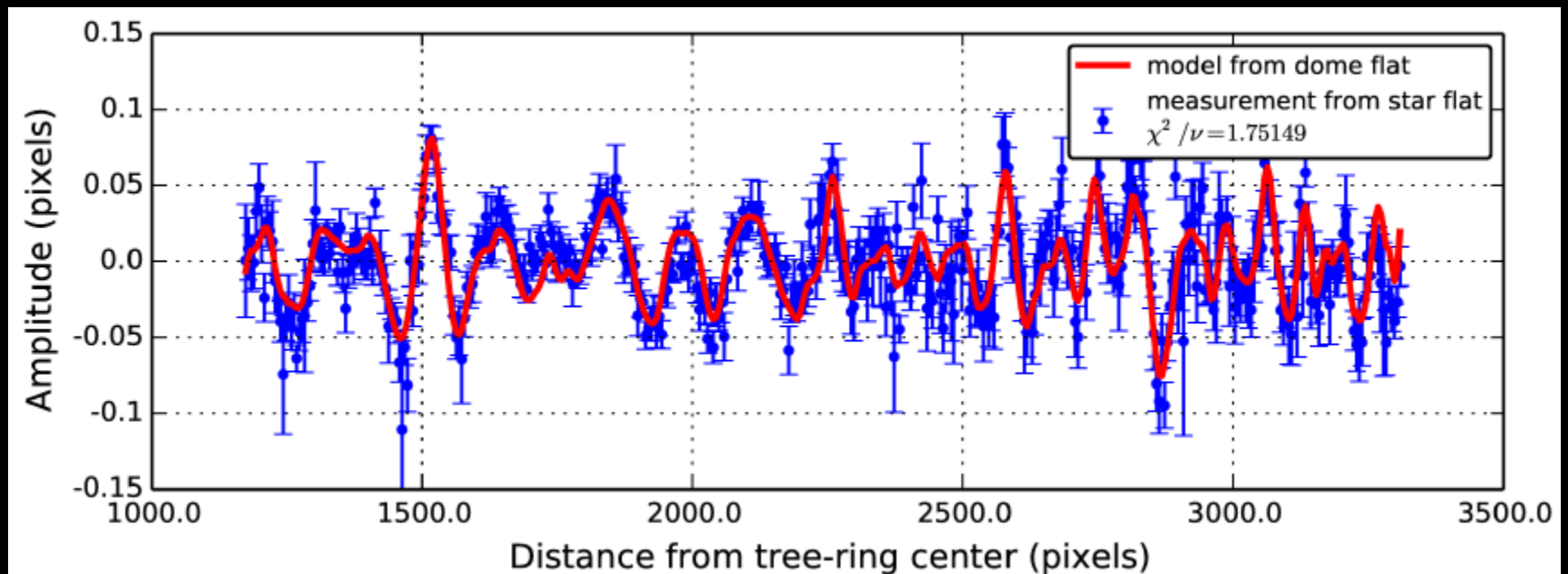
- This figure is a absolute value of spurious shear estimated from the model. Spurious shear from Tree Ring can be estimated by differentiating the displacement model, but the model is not a functions, is a table data, so here differences of displacement between next pixel were used as the differentiation.



Absolute shear from Tree Ring

Residuals from the model

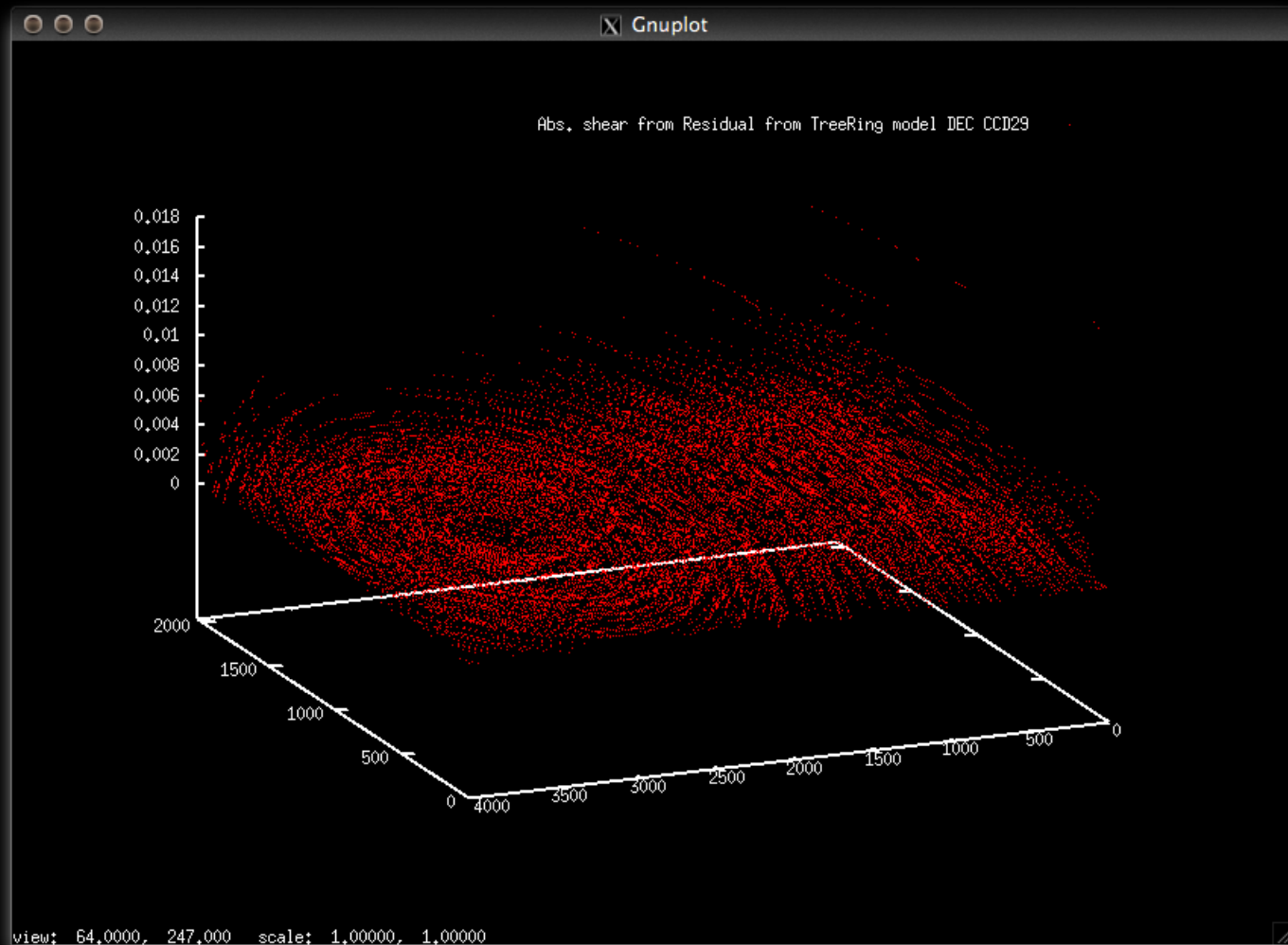
- Distortion components estimated by the model can be corrected by image warping. So we need to consider spurious shear from residual from the model. Blue point – red line is the residuals of the displacement, but it contains noise fluctuations and the fluctuation in small scale length makes large value in differential function.



The predicted displacement from flat image and measured displacement
(Plazas et al., 2014)

Shear from residual from Tree Ring model

- Some of the spurious shears from the residual are larger than from models. Typical scale of the shear is 0.003.



Absolute shear from residual

Issues for estimating spurious shear from residuals

- Small scale noise :

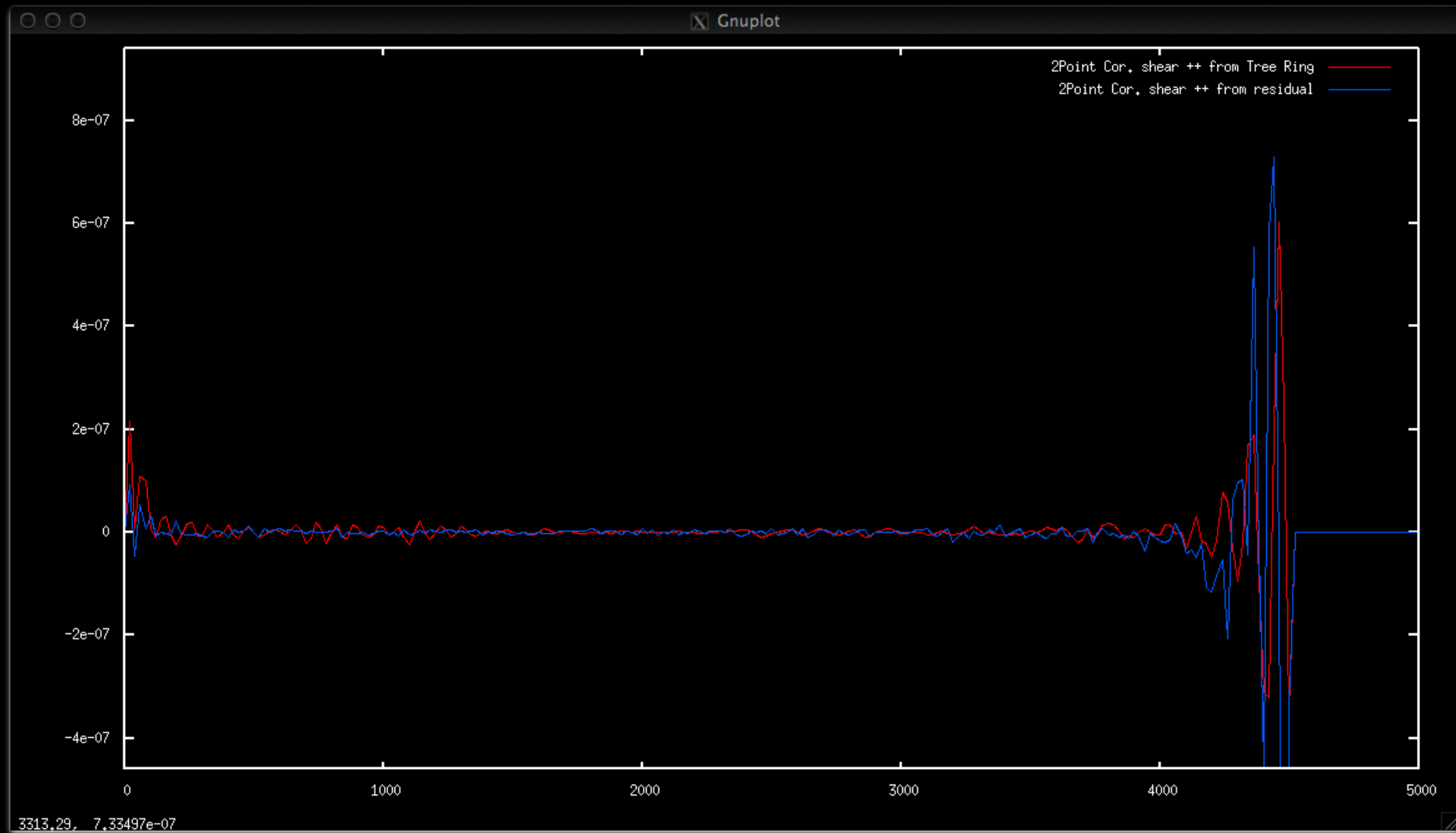
Random noises in small scale length make large effect, because the counts of the noise change frequently. So we need to use averaging or smoothing or something to reduce the effect, but large scale averaging also reduces effect from residuals. I'm not sure how large scale is best for the averaging. So in this test, I used 5 pixels for averaging.

- PSF Correction :

The distortion changes the shape of object image, and to estimate shear, we need to correct PSF effect in shape of image. So spurious shear effect gains by the correction, but it depends on PSF condition and size of images. Typical scale of the gain is $2 \sim 3$. In this test I didn't consider this effect.

2point shear correlations from Tree Ring

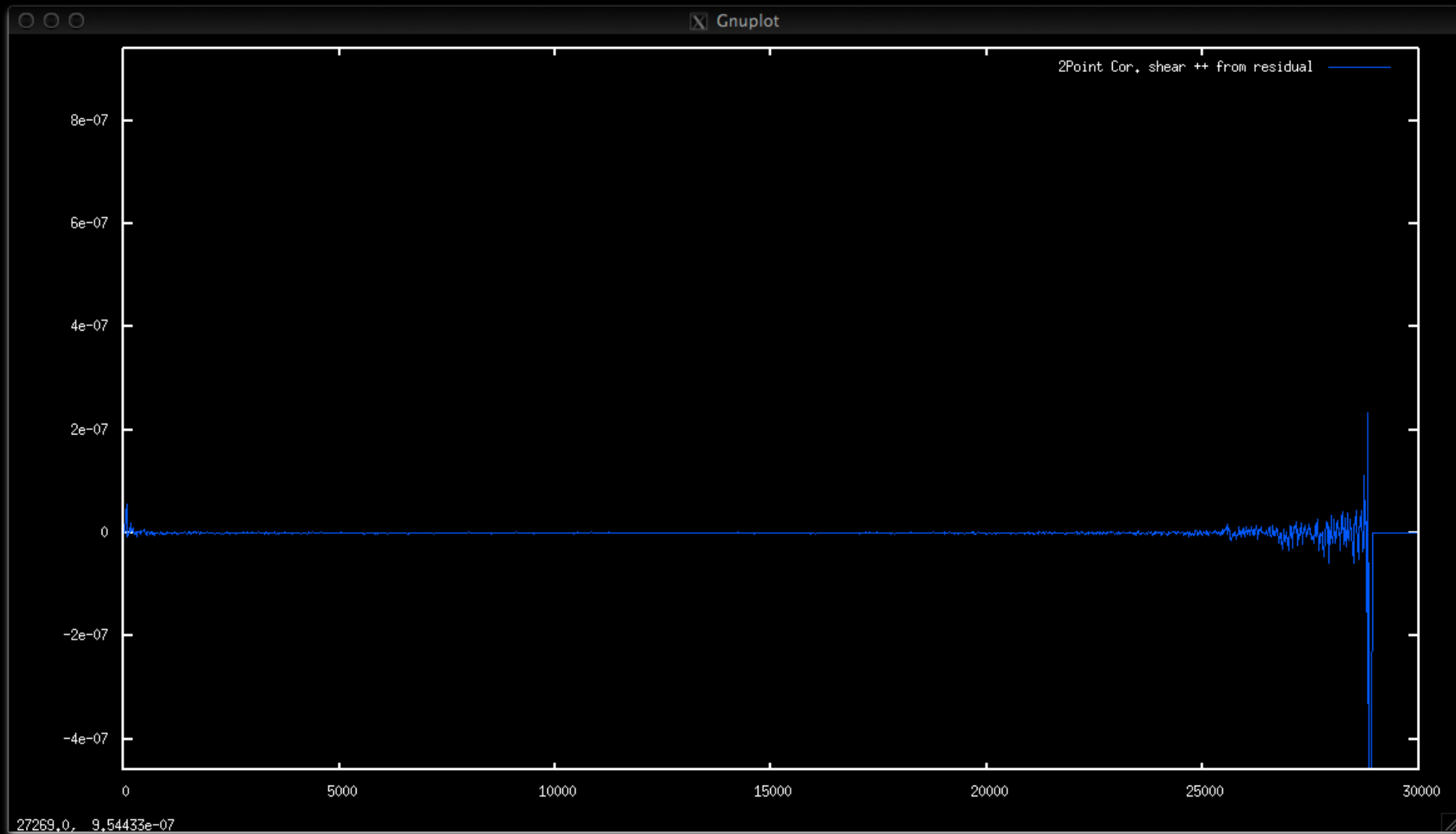
- Red is from Tree ring model, and blue is from residuals. 2point correlation of spurious shear is almost 0.



2point shear correlation from Tree Ring model and residual of DEC CCD29

2point shear correlations from Tree Ring

- The correlation in FOV of DEC is also almost 0. It's very smaller than $0.003 \times 0.003 \sim 10^{-4}$. Spurious shear varies positive and negative frequently, so the correlation canceled out?



2point shear correlation in FOV of DEC from residual

Summary and Future Works

Summary :

- Spurious shear can be estimated from differential of displacement by Tree Ring.
- By using Andres's models, we can correct the displacement by image warping, so the residual from the model was considered.
- But the residual has small scale length noise which has large effect, how to reduce only the noise effect is still a issue. I used 5pixel averaging in this study.
- Typical scale of the spurious shear from residual is 0.003.
- But typical scale of 2point correlation of the shear is under than 10^{-8} , it is very smaller than 10^{-4} (typical scale from cosmic shear), even if we consider PSF effect, the correlation will be negligible.

Future Works :

- Simulating shear and it's correlation on LSST CCDs.
- To estimating displacement by Tree Ring on LSST CCD, the fluctuation of the Tree Ring is needed, because the scale of displacement is related to the scale of the fluctuation.